Seismic Reflection Studies of Sediment Thickness Around the Hawaiian Ridge[1]

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DURING THE SPRING AND SUMMER of 1964, seismic profile surveys of sediment thickness were made on board the Research Vessel "Neptune I" around the Hawaiian Ridge. The seismic-reflection profiling techniques were based on a shallow explosive sound source of ½-lb blocks of TNT. The recording equipment was a modified facsimile drum recorder similar to that described by Ewing and Tirey (1961). The detector was an array formed with eight hydrophones enclosed in an oil-filled polyvinyl-chloride tube.

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The positions of seven tracks along which data were obtained are shown in Figure 1. The data obtained are presented in Figures 2, 3, and 4 in the form of profiles, with the vertical scales showing two-way travel time in seconds and the horizontal scales indicating position time for the vessel in hours. No corrections have been made for variations in the velocity of sound in sea water.

Because sedimentary velocities are not well determined for the area around the Hawaiian Swell, an average velocity of 2 km/sec has been assumed, based on available data from refrac-

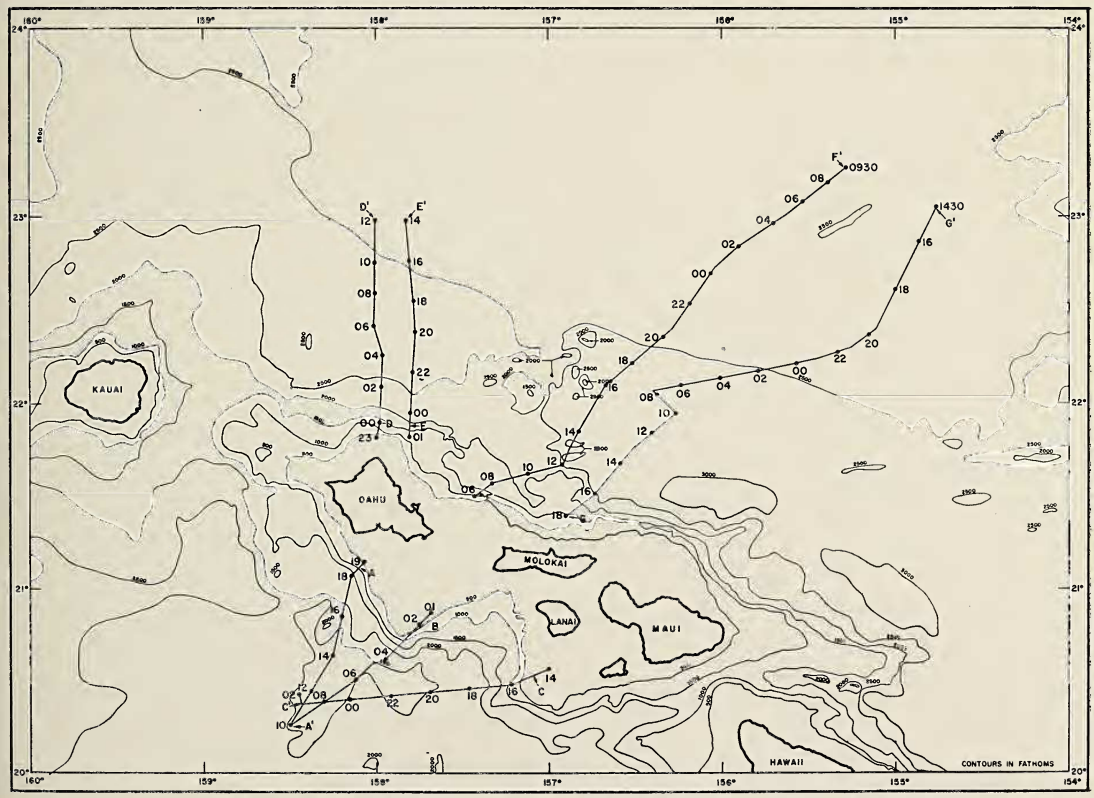

FIG. 1. Chart showing tracks of R/V "Neptune I," with 2-hourly positions, during seismic reflection profiling cruises.

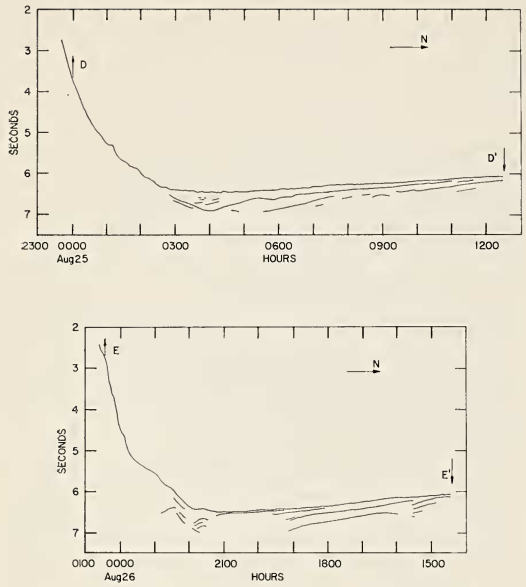

FIG. 2. Seismic reflection profiles north of Oahu.

tion seismic measurements made mostly north of the Hawaiian Ridge.

Little to no thickness of sediments is indicated in the shallow water over Penguin Banks southwest of Molokai. The area appears to be characterized by a high degree of bottom reflectivity, and high reverberation level. This may have masked any thin veneer of sediment that might be present. On the island shelf north of Molokai and Maui and within the Molokai Channel, sporadic sediment accumulation occurs and varies from 100–160 m in thickness. This appears to be concentrated in pockets and channels along the shelf. For the most part, the bottom again exhibits a relatively high degree of reflectivity.

Reefs are thought to be observed at the south edge of Penguin Banks southwest of Molokai and at the edge of the shelf north of Maui. Southwest of Molokai the reef appears to be 230 m thick, with the top lying 500 m below sea level. North of Maui the reef appears

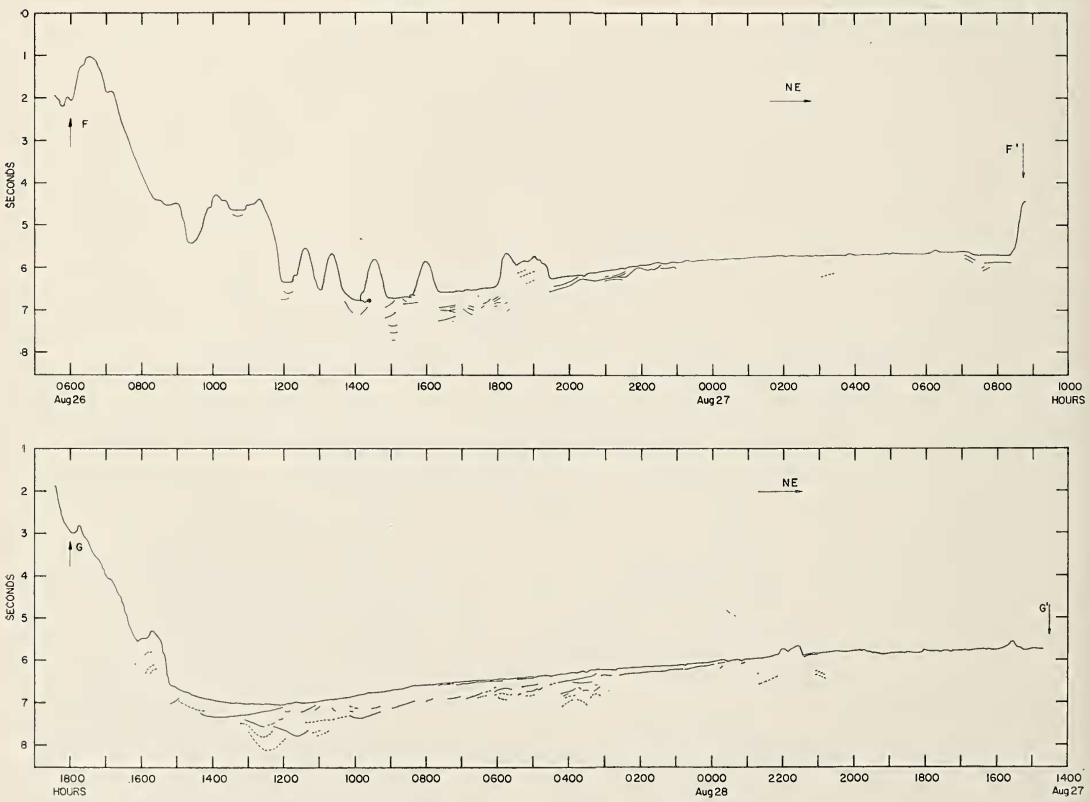

FIG. 3. Seismic reflection profiles northeast of Molokai.

to be 90 m thick, with the top 440 m below sea level. No bottom samples were obtained to verify the profile results. However, Menard et al. (1962) have reported Miocene (?) fossils dredged southwest of Honolulu at a depth of 500 to 520 m. If the seismically defined reefs are real and could all be shown to be of equivalent age, differential subsidence along the length of the Hawaiian Ridge, of at least 440 m north of Maui to 500 m south of Oahu, is indicated since the advent of reef formation. In their paper, Menard et al. suggest that dredge-hauls south of Oahu were from a Miocene reef *in situ*. If this is true, then approximately 0.5 km of subsidence has occurred since Miocene time, which leaves at least 1.5–2.5 km of subsidence to be explained as having occurred before reef formation (to be in accord with the total subsidence of 2–3 km suggested by seismic-refraction measurements).

The fact that subsidence of more than 0.5 km has taken place is also shown by the reflection measurements in the flanking trench-areas to the north and south of the Hawaiian Ridge. In both areas a considerable thickness of sediments is indicated. Two parallel profiles made due north of Oahu (Fig. 2) show depths to the lowest sub-bottom reflecting layer to be in excess of 600 m within the deeps, thinning to less than 100 m up the south flank of the Hawaiian Arch. A similar situation is observed on two profiles northeast of Molokai (Fig. 3). Here the deepest sub-bottom reflecting layer appears to be in excess of 1 km, thinning to zero as the crest of the Arch is reached.

These results are in agreement with the conditions postulated by Shor and Pollard (1964) from seismic refraction measurements.

South of the Hawaiian Ridge the sediment thickness varies from 100–200 m in thickness. Probably this indicates a less active environment of deposition, as the over-all picture is similar to that north of the Ridge. Both north and south of the Hawaiian Ridge the sediment thickness increases as the base of the Ridge is approached. Although it is more obvious in the northern profiles, the sub-bottom topography continues to dip toward the Ridge on both sides until the base of the slope is encountered. This is suggestive of faulting at the base of the slope. An alternate explanation would be a simple migration of the axis of a depositional basin inward toward the Hawaiian Ridge as the Ridge sank. Although slumping or volcanic flows appear to mask most of the base of the Ridge, the sub-bottom sedimentary structure strongly suggests progressive downwarp-

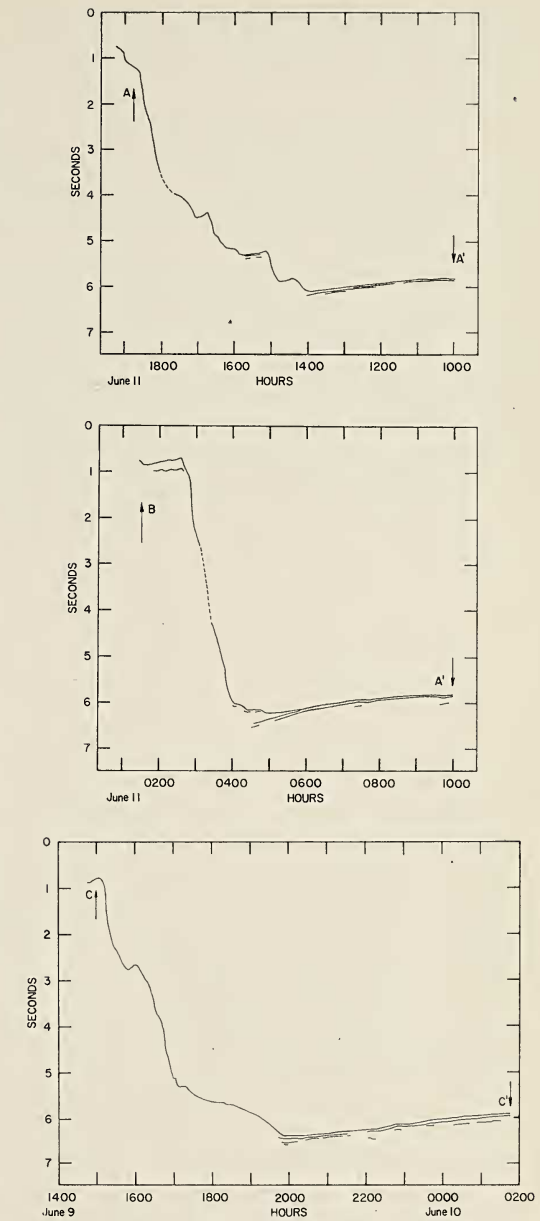

FIG. 4. Seismic reflection profiles south of Oahu (*A, B*) and Molokai (*C*).

ing of the crust on both sides of the Hawaiian Rise as the island platform of the Ridge was built up.

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